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Production of Mungbean (*Vigna radiata* L.) as Affected by Nitrogen and Phosphorus Fertilizer Application

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Abstract: In order to investigate the effects of different nitrogen and phosphorus levels on yield and yield components of mungbean variety Partow a field experiment was conducted at the Research Farm of the Islamic Azad University of Shahre-rey, in Tehran, Iran in 2009. The experiment was laid out with factorial arrangement in a Randomized Complete Block Design with three replications. Five levels of nitrogen (0, 30, 60, 90 and 120 kg N ha^{-1}) and six levels of phosphorus (0, 30, 60, 90, 120 and 150 kg P_2O_5 ha^{-1}) were the treatment variables. Results showed that application of N and P fertilizers significantly increased the seed yield. The maximum seed yield (224.2 g m^{-2}) was obtained when 90 kg N ha^{-1} and 120 kg P_2O_5 ha^{-1} was applied. This increase in seed yield was mainly due to more number of pods $plant^{-1}$, number of seeds pod^{-1} and 1000 seeds weight. Thus, application of 90 kg N ha^{-1} and 120 kg P_2O_5 ha^{-1} seems to be optimum levels for harvesting highest yield of mungbean.

Key words: Mungbean (*Vigna radiata* L.), nitrogen, phosphorus, yield, yield components

INTRODUCTION

Mungbean (*Vigna radiata* L.) is an important pulse crops having high nutritive value. It not only plays an important role in human diet but also in improving the soil fertility by fixing the atmospheric nitrogen (Ather Nadeem *et al*., 2004). Its seed is more palatable, nutritive, digestible and non-flatulent than other pulses (Anjum *et al*., 2006). In Iran, mungbean production is often undertaken on small farms using marginal soils low in N and P and with minimal technical inputs. In addition, the nodulation of mungbean is poor under the agro-ecological conditions of Iran. Fertilizer is one of the most important factors that affect crop production. Fertilizer recommendation for soils and crops is a dynamic process in view of the generation of the new knowledge, changes in soil nutrient status, changes in plants and planting patterns and associated management practices (Rafiqul Hoque *et al*., 2004). The management of fertilizers is one of the important factors that greatly affect the growth, development and yield of mungbean (Asaduzzaman *et al*., 2008). Nitrogen and phosphorus are both integral components of virtually all the biochemical compounds that make plant life possible. There is no conceivable alternative to these two elements in constructing the biochemical machinery of plants. It is absolutely clear that both N and P are essential elements in their structural, biochemical and physiological roles contributing to crop growth (Sinclair and Vadez, 2002). Nitrogen is an important major nutrient element for plant. For legumes, it is more useful because it is the main component of amino acids as well as proteins. Adequate supply of nitrogen is essential for normal growth and yield (Mozumder *et al*., 2003). Without N it is not possible to synthesize the necessary proteins, enzymes, DNA and RNA required in virtually all plant cells for their initial development, sustained growth and functioning to support other tissues of the plant. So, deficiencies in reduced N necessarily results in less biochemical machinery to catalyze plant metabolism and to generate new cells. Consequently, nitrogen deficiencies result in decreased crop leaf area, photosynthetic assimilation and seed growth (Sinclair and Vadez, 2002).

Several studies suggested that plant growth in most temperate ecosystems is limited by nitrogen or a combination of N and water. Moreover, under N enriched conditions phosphorus availability has been shown to limit plant growth (Reed *et al*., 2007). Phosphorus is one of the three macronutrients that plants must obtain from the soil. It is a major component of compounds whose functions relate to growth, root development, flowering and ripening (Sompong *et al*., 2010). Among the soil nutrient elements, P is the second most essential nutrient after the nitrogen.

Many studies have shown that application of phosphorous fertilizers generally has great impact on crop yields because its deficiency limits the response of plants to other nutrients (Akinrinde and Adigun, 2005).

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Phosphorus is an essential component of cell structures, mainly as nucleic acids and phospholipids (Sinclair and Vadez, 2002). It is especially critical in establishing the enzymatic machinery in energy storage and transfer, which in many cases involves membrane processes. Not surprisingly, P deficiency results in a loss in cell integrity. The bonding properties of P also make it crucial for metabolic processes that are nucleotide-based, e.g., ADP, NAD and NADP, because of its unique energy-transfer properties. A general consequence of P deficiency is a decrease in the energy charge of cells (Sinclair and Vadez, 2002). Crop growth in tropical soils is often limited by low P availability and the recovery of P applied as fertilizers by crops is usually very low, because most P becomes unavailable due to adsorption, precipitation or conversion to organic forms (Araújo *et al*., 2005). Ayub *et al*. (1999) recorded the maximum seed yield (31% higher than control) of mungbean at 40 kg N ha^{-1} application. The increase in seed yield with nitrogen application was related to higher number of pods $plant^{-1}$, number of seeds pod^{-1} and 1000-grains weight. Mozumder *et al.* (2003) showed that increase of nitrogen up to 40 kg N ha^{-1} increased seed yield of mungbean. Ather Nadeem *et al.* (2004) found that the application of fertilizer significantly increased the seed yield and maximum seed yield was obtained when 30-60 kg N-P_2O_5 ha^{-1} was applied. Phosphorus is considered the most important nutrient for increasing yield of mungbean. Studies have shown that phosphorus application to mungbean has increased plant height, number of branches, number of pods $plant^{-1}$, number of grains pod^{-1}, 1000-grains weight, biological yield and grain yield (Ayub *et al*., 1998). Khan *et al*. (1999) also reported that phosphorus application significantly increased the yield of mungbean. Khan *et al.* (2002) found that maximum increased in total biomass and yield of mungbean was obtained with phosphorus application at 100 kg P_2O_5 ha^{-1}. Ali *et al.* (1999) applied 0, 35, 60 and 85 kg ha^{-1} phosphorus to mungbean and obtained highest seed yield with phosphorus application of 85 kg P_2O_5 ha^{-1} but was statistically similar to 65 kg P_2O_5 ha^{-1}. Sharar *et al*. (1999) concluded that phosphorus application at 100 kg P_2O_5 ha^{-1} produced the maximum yield and its components of mungbean cultivars. Tariq *et al*. (2001) reported that grain yield and its components of mungbean were increased significantly by application of phosphorus at 70 kg P_2O_5 ha^{-1}. The degree of nodulation, fixing atmospheric nitrogen and so, fertilizers requirement varies with the soil and climatic conditions, cultivar, cultural operations and etc., thus the objective of this study is to determine suitable levels of nitrogen and phosphorus fertilizers for realizing the maximum yield potential of mungbean variety Partow under Shahre-rey region conditions at Iran.

MATERIALS AND METHODS

This study was conducted at the research farm (35°-35' N and 51°-28' E. a.s.l. of 1000 m), the Islamic Azad University of Shahre-rey, in Tehran, Iran, in the 2009. The mean annual precipitation and temperature are 201.7 mm and 20.4°C, respectively. The soil of experimental field was sandy clay loam with pH 7.8 and contains organic matter 1.1%, total nitrogen 0.071%, available phosphorus 7.9 ppm, exchangeable potassium 310 ppm and EC of 2.7 mmohs cm^{-1}. The experiment was laid out with factorial arrangement in a randomized complete block design with three replications which five levels of nitrogen (0, 30, 60, 90 and 120 kg N ha^{-1}) and six levels of phosphorus (0, 30, 60, 90, 120 and 150 kg P_2O_5 ha^{-1}) were the treatment variables. Sowing procedure was done on June 27, 2009 with a single row hand drill in 50 cm apart rows with plant to plant distance of 10 cm. Size of each plot was 15 m^2 (5×3 m).

Nitrogen and phosphorus were applied in the form of urea and triple super phosphate, respectively. Half dose of nitrogen and full dose of phosphorus fertilizer was applied as basal at the time of sowing by side dressing with the help of hand drill, while remaining half nitrogen was top dressed 40 days after sowing.

All other cultural practices were kept normal and uniform for all treatments. At physiological maturity, 10 plants $plot^{-1}$ were selected randomly, sun dried and were recorded number of pods $plant^{-1}$, number of seeds pod^{-1} and 1000 seeds weight. To determine seed yield, plants were harvested by hand from pre demarcated two rows of each plot that were sun dried properly. Collected data were analyzed statistically using MSTAT-C statistical software and the means were compared by Duncan's Multiple Range Test at the 5% probability level (Steel and Torrie, 1980).

RESULTS

Number of pods $plant^{-1}$: Various nitrogen levels produced significant differences ($p \le 0.01$) on the number of pods $plant^{-1}$. The application of nitrogen at the rate of 120 kg N ha^{-1} produced significantly higher number of pods $plant^{-1}$ (21.76) than the other levels. The number of pods $plant^{-1}$ were also influenced significantly ($p \le 0.01$) by phosphorus application. The maximum number of pods $plant^{-1}$ (21.34) were obtained from plots receiving 150 kg P_2O_5 ha^{-1} (Table 1).

Table 1: Effect of nitrogen and phosphorus levels on yield and yield components of mungbean

Treatments	No. of pods plant^{-1}	No. of seeds pod^{-1}	1000-seeds weight (g)	Seed yield (g m^{-2})
N (kg ha^{-1})				
0	12.65e	6.69e	41.19e	70.5e
30	15.53d	7.18d	43.73d	99.0d
60	19.06c	7.73c	46.02c	139.6c
90	21.23b	8.02b	47.39b	167.2b
120	21.76a	8.13a	47.90a	175.1a
P_2O_5 (kg ha^{-1})				
0	11.53f	6.48f	40.38f	60.4f
30	15.66e	7.22e	43.71e	101.1e
60	18.83d	7.72d	45.75d	136.7d
90	20.00c	7.85c	46.65c	151.6c
120	20.93b	7.95b	47.26b	163.0b
150	21.34a	8.08a	47.73a	168.9a

Means with the same letter(s) in each column and treatment are not significantly different at probability level of 5% using DMRT

Table 2: Interaction effects of nitrogen and phosphorus levels on yield and yield components of mungbean

Dosages (N-P_2O_5 kg ha^{-1})	No. of pods plant^{-1}	No. of seeds pod^{-1}	1000-seeds weight (g)	Seed yield (g m^{-2})
0×0	10.18w	6.02q	38.98z	47.6x
0×30	10.59vw	6.07q	39.58z	50.6x
0×60	13.09qr	6.94m	41.72u	75.5t
0×90	13.56pq	7.01l	41.85u	79.3s
0×120	13.99op	7.02l	42.27t	82.8s
0×150	14.49no	7.07kl	42.75s	87.3r
30×0	10.98uv	6.27p	39.97y	54.8w
30×30	15.00mn	7.13k	43.23r	92.1q
30×60	15.73lm	7.20j	43.80q	98.9p
30×90	16.26kl	7.24ij	44.33p	104.1o
30×120	16.81jk	7.31i	44.82o	109.8n
30×150	18.42gh	7.91f	46.26l	134.4k
60×0	11.70tu	6.49o	40.54x	61.3v
60×30	17.11j	7.39h	44.95o	113.3n
60×60	19.01g	7.94f	46.76k	140.7j
60×90	20.64f	8.03e	47.19j	155.8i
60×120	22.74de	8.25c	48.05h	179.8g
60×150	23.15d	8.30c	48.65g	186.4f
90×0	12.19st	6.79n	40.99w	67.6u
90×30	17.58ij	7.60g	45.23n	120.5m
90×60	22.15e	8.12d	47.51i	170.4h
90×90	24.49bc	8.45b	49.54e	204.4d
90×120	25.76a	8.61a	50.67a	224.2a
90×150	25.18ab	8.55a	50.40cd	216.2bc
120×0	12.58rs	6.83n	41.40v	70.9u
120×30	18.00hi	7.89f	45.56m	129.0l
120×60	24.16c	8.40b	48.97f	198.0e
120×90	25.03ab	8.54a	50.35d	214.4c
120×120	25.34a	8.56a	50.51bc	218.3b
120×150	25.43a	8.58a	50.61ab	220.1b

Means with the same letter(s) in each column are not significantly different at probability level of 5% using DMRT

The interaction effects of N and P_2O_5 levels on number of pods plant^{-1} were significant ($p \leq 0.01$). The highest number of pods plant^{-1} (25.76) were recorded in plots where N and P_2O_5 were applied at 90 and 120 kg ha^{-1}, respectively.

However, differences among these treatment combinations and 90-150, 120-90, 120-120 and 120-150 kg N-P_2O_5 ha^{-1} were not significant (Table 2).

Number of seeds pod^{-1}: The application of 120 kg N ha^{-1} produced significantly higher number of seeds pod^{-1} (8.13) than the other nitrogen levels. Also, the effect of different phosphorus levels on number of seeds pod^{-1} was significant ($p \leq 0.01$). The treatment of 120 kg P_2O_5 ha^{-1} gave maximum number of seeds pod^{-1} (8.08) (Table 1). The interaction effects of N and P_2O_5 levels on number of seeds pod^{-1} were significant ($p \leq 0.01$). The highest number of seeds pod^{-1} (8.61) were recorded by 90-120 kg N-P_2O_5 ha^{-1}, which was statistically, similar with 90-150, 120-90, 120-120 and 120-150, kg N-P_2O_5 ha^{-1} (Table 2).

1000-seeds weight (g): Different N levels have a significant effects ($p \leq 0.01$) on 1000 seeds weight. The highest 1000 seeds weight (47.90 g) was recorded at 120 kg N ha^{-1} application. 1000-seeds weight was affected significantly ($p \leq 0.01$) by phosphorus application. In different phosphorus levels, the application of 150 kg P_2O_5 ha^{-1} produced highest 1000-seeds weight (47.73 g) (Table 1). The interaction effects of N and P_2O_5 levels on 1000-seeds weight were significant ($p \leq 0.01$). The highest 1000-seeds weight (50.61 g) were recorded in plots where, N and P_2O_5 were applied at 90 and 120 kg ha^{-1}, respectively, which was statistically, similar with 120-150 kg N-P_2O_5 ha^{-1} (Table 2).

Seed yield (g m^{-2}): Seed yield was affected significantly ($p \leq 0.01$) by various nitrogen levels. The maximum seed yield (175.1 g m^{-2}) was obtained by the application of 120 kg N ha^{-1}. The differences in seed yield among the various phosphorus levels were also significant ($p \leq 0.01$). The application of 150 kg P_2O_5 ha^{-1} produced highest seed yield (168.9 g m^{-2}) (Table 1). The interaction effects of N and P_2O_5 levels on seed yield were significant ($p \leq 0.01$). The highest seed yield (224.2 g m^{-2}) were recorded by 90-120 kg N-P_2O_5 ha^{-1} (Table 2).

DISCUSSION

Nitrogen is essential for plant growth and is a part of every living cell. It directly increases the plant protein content. Nitrogen helps make plants green and plays a major role in boosting crop yields. It plays a critical role in protein formation and is a key component of chlorophyll. Phosphorus is an essential nutrient for plant growth which stimulates blooming and seed formation (Akhtar *et al*., 1999). It plays a fundamental role in metabolism and energy producing reaction in plants. It is an integral part of nucleic acid, phytin and phospholipids and is essential for cellular respiration in the metabolism of the starch, protein and fats (Iqbal and Chauhan, 2003). Phosphate is made unavailable in arid soils principally as complex calcium compounds (Mehdi *et al*., 2003). With high rate of P fertilizer additions, soil sorption sites are satisfied and P level increase to sufficiency for crop production. This is of particular importance because of the role of P in plant nutrition; enhancing nitrogen absorption, influencing pod and seed formation in legumes and contributing significantly in plant energy processes (Anetor and Akinrinde, 2006). In present study, application of 90-120 kg N-P_2O_5 ha^{-1} produced highest number of pods $plant^{-1}$. Significant differences of nitrogen application on the number of pods $plant^{-1}$ have been reported by Ayub *et al.* (1999). Ali *et al.* (1999) have also found an increase in number of pods $plant^{-1}$ with phosphorus application in mungbean. Khan *et al.* (1999) reported that application of 120 kg P_2O_5 ha^{-1} increased the number of pods $plant^{-1}$ in mungbean. Ayub *et al.* (1998) reported that the application of P_2O_5 at the rate of 75 kg ha^{-1} remaining at par with 50 and 100 kg P_2O_5 ha^{-1} gave significantly higher number of pods $plant^{-1}$ than 0, 25 and 125 kg P_2O_5 ha^{-1}. Sharar *et al.* (1999) found that the maximum number of pods $plant^{-1}$ were produced at the rate of 100 kg P_2O_5 ha^{-1}. The positive effect of P_2O_5 application on number of pods $plant^{-1}$ might be due to various enzymatic activities which controlled flowering and pod formation (Khan *et al.*, 1999). The sink capacity of plants (number of pods $plant^{-1}$) has genetic limitation (Ayub *et al.*, 1998), that is why the number of pods $plant^{-1}$ not increased at higher nitrogen and phosphorus levels.

Number of seeds pod^{-1} is an important factor that directly involved in exploiting yield recovery in leguminous crops (Khan *et al.*, 1999). In this experiment, the maximum number of seeds pod^{-1} were recorded at the rate of 90-120 kg N-P_2O_5 ha^{-1}. Ather Nadeem *et al.* (2004) reported that all the fertilizer levels produced higher number of seeds pod^{-1} over control as the maximum number of seeds pod^{-1} were produced by 45-90 kg N-P_2O_5 ha^{-1}. Khan *et al.* (1999) reported that maximum seeds pod^{-1} was produced by application of 120 kg P_2O_5 ha^{-1}. Ayub *et al.* (1999) reported that the application of nitrogen at the rate of 40 kg N ha^{-1} produced significantly higher number of seeds pod^{-1} than all other treatments and the crop raised with the application of 20 and 60 kg N ha^{-1} produced statistically similar number of seeds pod^{-1} but significantly higher than control. Ayub *et al.* (1998) reported that the application of 75 kg P_2O_5 ha^{-1} produced significantly higher number of seeds pod^{-1}. The increase in the number of seeds pod^{-1} might be due to the positive response of phosphorus on flower setting and ultimately increased the seed number (Ayub *et al.*, 1998).

As known, seed weight (g) is an important yield component of the mungbean. In this study, application of 90-120 kg N-P_2O_5 ha^{-1} produced the highest 1000 seeds weight. Ayub *et al.* (1999) has also reported that the plots fertilized at the rate of 40 kg N ha^{-1} produced significantly higher 1000-seeds weight than all other nitrogen levels and differences between control and 20 kg N ha^{-1} were not significant. Sharar *et al.* (1999) reported that increase in P_2O_5 application up to 100 kg ha^{-1} increased 1000-seeds weight of mungbean. Khan *et al.* (1999) reported that maximum 1000-seeds weight of mungbean was produced by application of 120 kg P_2O_5 ha^{-1}. It is evident that with increase in the phosphorus level, the 1000-seeds weight was also increased which indicated that phosphorus application improve the seed weight. These results indicate that nitrogen and phosphorus application have influenced the physiological processes such as photosynthesis, that ultimately resulted in the fully filled seeds. Similar results have also been reported by Ather Nadeem *et al.* (2004).

Results of present study showed that the maximum of seed yield was recorded at the rate of 90-120 kg N-P_2O_5 ha^{-1}. Significant effects of nitrogen application on seed yield of mungbean have been reported by Ayub *et al.* (1999) and Ashraf *et al.* (2003). Ayub *et al.* (1999) obtained that maximum seed yield of mungbean was produced by application of 40 kg N ha^{-1}. Sharar *et al.* (1999) and Oad *et al.* (2003) obtained that the higher seed yield of mungbean was recorded at the rate of 100 kg P_2O_5 ha^{-1}. The increased in seed yield with N-P_2O_5 application had been due to higher number of pods $plant^{-1}$, seeds pod^{-1} and 1000-seeds weight. The decrease in seed yield beyond 90-120 kg N-P_2O_5 ha^{-1}, might be due to genetic inability of the cultivar to get more fertilizer or due to some nutritional imbalance. These findings are also in line with those of Ayub *et al.* (1998) and Sharar *et al.* (1999). Shah *et al.* (2006) and Khan *et al.* (1999) reported that maximum seed yield was produced by application of 120 kg P_2O_5 ha^{-1}. Khan *et al.* (2002) stated that seed yield was increased with phosphorus application. These results are supported by the findings of Ather Nadeem *et al.* (2004) and Ali *et al.* (1999), who have also reported an increase in seed yield with increased fertilizer levels.

CONCLUSION

The results of this experiment revealed that application of nitrogen and phosphorus fertilizers, increased number of pods $plant^{-1}$, seeds pod^{-1}, 1000-seeds weight (g) and seed yield (g m^{-2}) of mungbean. The application of 90-120 kg N-P_2O_5 ha^{-1} was found to be the optimum levels for obtaining highest yield of mungbean variety Partow under agro-ecological conditions of Shahre-rey region in Iran.

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